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Identification and Quantification of Non-Point Sources of pollution to Sabarmati River, Ahmedabad

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Abstract

"Whatever can be measure, can be control".Non-point pollution sources(NPS) account for more than 50% of the total water quality problem, and they are being recognized and investigated nationally and internationally. In many areas, non-point pollution, such as runoff from crop land, urban storm water, strip mining and runoff from construction sites are becoming major water quality problems.To identify and quantify Non-point sources of pollution the selected study area is the stretch of the Sabarmati river from gandhinagar to Ahmedabad city. The selected study area is divided into two parts. 1. The upstream of Ahmedabad city. 2. Ahmedabad city. Identification of NPS is done by literature survey and field visit of study area. Quantification can be done by using different runoff calculation methods. Because of limitations of all method, the appropriate one has been chosen for analysis. By quantifying it is observed that the NPS contribute the large amounts of pollution load which can not be underestimated.

As on today, there is no direct approach to estimate Non-point Pollution Sources. Even information available is not in direct useful form. So, there is need to develop system to estimate Non-point Pollution Sources in much simplified form.

Key words – Non-point pollution sources (NPS), Rational Method, Barlow's tables, Run-off

1. Introduction

Pollutant inputs have increased in recent decades, and the result has been degradation of water quality in many rivers, lakes and coastal oceans. This degradation shows up in the disruption of natural aquatic eco-system and the consequent loss of their component species as well as the amenities that these ecosystems once provided to society.

1.1 CLASSIFICATIONS OF SOURCES OF POLLUTION

The sources of pollution may be classified into two parts:

1. Point sources : "A point source is a stationary location or fixed facility from which pollutants are discharged or emitted or any single, identifiable discharge point of pollution, such as a pipe, ditch, or smokestack."

2. Non-point sources: "The term non-point source is used to identify source of pollution that are diffuse and do not have a point of origin or that are not introduced into a receiving stream from a standard outlet"

An interesting feature of non-point pollution is that – with few exceptions- the bulk of pollution is carried by surface runoff. Thus,the areas where surface runoff originates- called hydrologically active areas- also are sources of non-point pollution and should be subject to control and management.

Pollution from non-point sources is a hydrologic problem. It is a known fact that there is a close relationship of pollutant loadings from areal sources to the rain volume and intensity, infiltration and storage characteristics of watershed, and other hydrologic parameters. Unlike pollution from point sources, which bears little relation to the watershed hydrology, pollution from non-point sources has its beginning in the atmospheric transport of pollutants, and its occurrence and magnitude are closely related to the hydrologic cycle. Subsequently, the pollutant load from non-point sources has a random character. In addition, uncontrolled hydrologic modifications of watersheds caused by man can increase the non-point pollutant loads. On the other hand, hydrologic modifications aimed to reduce the hydrologic activity of lands are often effective for controlling excessive pollution.

2. Study area

Sabarmati river is located at 23^o 05" 0' N 72^o 38"00' E. The Sabarmati basin extends over an area of 21,674 sq km. The total length of the river from the head to its outfall into the sea is 371 km. The principal tributaries of the river are the Sei, the Wankal, the Harnay, the Hathmati, and the Vatrak and the Meshwa.



Figure 1. Satellite image of study area

The River Sabarmati is one of the most polluted rivers in the country although it is the lifeline of the State of Gujarat. Intensive agricultural practices coupled with intensive withdrawal of water for cropping had left the river absolutely dry after it entered the Ahmedabad city limits. The river is in a very serious state and deserves urgent attention.

The study area is bounded up to Upstream of Ahmedabad city from Indira bridge (Indroda/Gandhinagar to Indira bridge stretch).

3. Identification of NPS

Identified nonpoint pollution sources of the study area are as follows based on literature and field visits.

1. Surface Run-off
2. Other wastes
    - Waste from religious activities
    - Dhobi Ghats
    - Animal Waste(Bathing of Animals)
    - Vehicle washing

4. Quantification of NPS

The line which divides the surface runoff between two adjacent river basins is called the topographic water divide, or the watershed divide, or simply the divide. The divide follows the ridge line around the basin crossing the stream only at the outlet point. It marks the highest points between the basins, but isolated peaks within the basin may reach higher elevations than any point on the divide.

The subsurface runoff generated by the rain falling between the topographic divide as shown in fig will flow into the stream of catchment

From the image the estimated catchment area of the river for the defined study area is 126 km^2 as shown in fig 2.



Figure 2. GIS image of catchment area

4.1 Methods to calculate run-off

There are different methods available to calculate the surface run-off. There are 3 methods to calculate run-off.

1. Rational Method
2. Computing Run-off using run-off coefficient
3. Barlow's Table method

Table 1 shows different available methods with their formula, description and limitations.

In this paper, to calculate run-off the average yearly rainfall of Ahmedabad city is adopted. The calculation of run-off for last 8 years i.e. from 2005 to 2012 is calculated for the defined study area by Barlow's table method which is shown in Table 3.

The run-off from a catchment can be expressed from Barlow's table method is as:

$$\mathbf{R = K_b P}$$

Where, P= monsoon rainfall

K_b = run-off coefficient

The value of Run-off coefficient is shown in table 2.

Table 3 shows the surface run-off of the last 8 years of the given study area. It is estimated that this run-off carries large amount of nutrients and pesticides as agriculture is the main activity of this study area. This run-off contributes the amount of water to the river Sabarmati.

5. Conclusion

Non-point pollution sources contribute a large amount of pollution load to the river Sabarmati. Run-off contains nutrients and pesticide which is directly affects the river water quality. The river water quality degraded because of this pollution load. So, there is a need to develop a Best Management Practices for agriculture activity and also to introduce policy to control non-point sources of pollution.

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Table 1. Methods to calculate run-off

Sr no	Method name	Description	Formula	Limitation
1	RATIONAL METHOD	For determination of the peak flow rate. This method was originally developed for urban catchments	Q = CIA in which, Q = the maximum rate of runoff K = a runoff coefficient that is the ratio between the runoff volume from an area and the average rate of rainfall depth over a given duration for that area I = average intensity of rainfall in inches per hour for a duration equal to the time of concentration, tc A = area	This method is fairly applicable to small agricultural watersheds of 10-50 km^2 size.
2	COMPUTING RUNOFF BY USING RUNOFF COEFFICIENT		The volume of runoff can be directly computed approximately, by using an equation form Q= KP Where, Q = Runoff P = precipitation K = a constant, depending upon the imperviousness of the drainage area	Used in the design of storm water drains and small water control projects, especially for urban areas. Should be avoided rural areas and for analysis of major storms.
3	BARLOW'S TABLES		The run-off from a catchment can be expressed as: $R = K_bP$ Where, P= monsoon rainfall K_b = run-off coefficient	This method is applicable for small catchment areas less than 140 km^2 size.

Table 2. Barlow's Table of Runoff Coefficient K_b in percentage

Class	Description of Basin	K_b in percentage		
		Season 1	Season 2	Season 3
A	Flat, Cultivated and black cotton soils	7	10	15
B	Flat, partly cultivated various soils	12	15	18
C	Average catchment	16	20	32
D	Hills and plains with little cultivation	28	35	60
E	Very hilly, and steep with hardly any cultivation	36	45	81

Table 3. Run-off calculation

Year	Rainfall (mm)	Run-off ($R= K_bP$)(mm)	Volume= R*A (m^3 / year)
2005	1240.13	186.01	23.4×10^6
2006	1217.85	182.6	22.9×10^6
2007	986.81	148.02	18.6×10^6
2008	667.77	100.16	12.6×10^6
2009	467.01	70.05	8.8×10^6
2010	1195.91	179.38	22.5×10^6
2011	706.63	105.99	13.2×10^6
2012	669.66	100.44	12.6×10^6